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VERIFICATION OF TRANSLATION

I hereby declare and state that I am knowledgeable of each of the German and English languages and that I made and reviewed the attached translation of a patent application entitled "Light Unit and Method for Generating Light Beams" from the German language into the English language, and that I believe my translation to be accurate, true, and correct to the best of my knowledge and ability.

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Translator

Light Unit and Method for Generating Light Beams

The present invention relates to a light unit according to the preamble of Claim 1 and a method for generating light beams.

The generation of laser beams having various wavelengths using the same laser unit is known in and of itself. Thus it has already been proposed to split the laser beam of a white light laser with the aid of filters or prisms in order in this way to extract the desired color components, that is, wavelengths. It is further known to alter the dimensions of the resonator present in laser units with the aid of a corresponding mechanical system, so that the wavelength of the generated laser light can also be altered, but only from one mode to another. In relation to white light or respectively colored light laser, reference is made to a press release from the University of Bonn, Germany, dated September 16, 2003. Therein is described a new laser with which white light can be generated in simple fashion and at low cost. The white light is decomposed into the color components with the aid of a suitable prism, it then being possible to select the required color. In relation to the first-named technique, reference is made to the publication by Jeff

Hecht entitled "Understanding Lasers" (IEEE Press, 1992, pp. 296-297).

The known laser units, however, exhibit unsatisfactory properties, specifically both with respect to the possibility of being able to set a certain wavelength and also with respect to the coherence of the laser beams obtained.

Further, laser units are known in which, with the aid of a pressure element, a lateral pressure is exerted on the active layer of a semiconductor in order to alter the wavelength of the emitted light. In this connection, reference is made to the following publications:

— FR-1 382 706;

— JP-63 066 983;

— publication by S. Komiyama and S. Kuroda titled "Remarkable effects of uniaxial stress on the far-infrared laser emission in p-type Ge" (Physical Review, B. Condensed Matter, American Institute of Physics, New York, U.S.A., Vol. 38, No. 2, July 15, 1988, pages 1274 to 1275).

With known laser units, the wavelength can be varied only within a relatively small range, as is inferred

in particular from the results described in the last-named publication.

Further, there are known laser units in which the wavelength is varied by displacement of one or a plurality of mirrors. In this connection, reference is made to DE-42 15 797 A1, US-6 396 083 B1 or US-2003/0012249 A1 as being representative. Even in the case of these known laser units, however, the wavelength can be varied only within a certain range, specifically by selecting one mode of the laser.

It is therefore a goal of the present invention to identify a light unit that does not exhibit the aforesaid disadvantages.

This goal is achieved through the measures cited in the characterizing part of Claim 1. Advantageous developments of the invention and a method for generating light beams having various wavelengths are cited in further claims.

The invention has the following advantages: In that the mirror unit and/or the exit window are displaceable relative to the support unit and/or tiltable relative to the longitudinal axis by at least one displacement element in dependence on the force generated on the light source unit by the pressure-generating element,

the possibility of being able to set the wavelength of the light beams over a wide range is created. Thus an exact setting of the wavelength of a light unit is possible through the combination of the setting of the wavelength via the force on the light source unit with simultaneous displacement of the exit window and/or the mirror unit along the longitudinal axis of the support unit, which setting far surpasses former setting capabilities.

If, in addition, a laser diode unit is used as the light source unit, the prerequisite is satisfied for the first time for being able to obtain maximally coherent light by setting the spacing between the mirror unit and the exit window as a multiple of half the wavelength set via the pressure-generating element.

In what follows, the invention is described in greater detail with reference to the embodiments illustrated in the drawings. These are exemplary embodiments that aid in understanding the subjects claimed in the claims. In the drawings:

Figure 1A depicts, in schematic and perspective representation, a part of a light unit, one cutting plane lying parallel to a longitudinal axis

and another cutting plane lying transversely to the longitudinal axis;

Figure 1B depicts, in schematic and perspective representation according to Figure 1A, a part of a further embodiment of a light unit;

Figure 2 depicts an exit window for employment in the part of the light unit illustrated in Figure 1A or 1B;

Figure 3 depicts the exit window of Figure 2 in a section parallel to the longitudinal axis according to Figure 1A or 1B;

Figure 4 depicts the fully assembled light unit according to Figures 1A, 1B, 2, and 3;

Figures 5A and 5B each depict a section transverse to the longitudinal axis of a light unit; and

Figure 6 depicts a schematic representation of a variant embodiment according to the invention, in which a mirror unit and an exit window are always arranged centrally in relation to a light source unit.

In the discussion that follows, a laser unit is described as a special case of a light unit. The light source is here defined such that it does not necessarily generate light beams that satisfy the conditions imposed on laser beams. Not so, in particular, even when—as provided in one embodiment—a laser diode unit is used as light source unit in the light source. Thus, for the explanation of specific embodiments in which laser beams are not generated, the term "laser unit" can basically be replaced by "light unit" without in this way altering the principle according to the invention.

In Figure 1A, a laser unit 2 according to the invention is illustrated. This is a semiconductor laser unit based for example on gallium arsenide. Laser unit 2 according to the invention is distinguished by high target accuracy. It is possible, for example, to generate wavelengths from 400 nm to 700 nm using laser unit 2 according to the invention.

Figure 1A depicts the schematic structure of a part of laser unit 2 with reference to a section parallel to a longitudinal axis 40. The light waves generated as laser beams propagate parallel to longitudinal axis 40; a mirror unit and an exit window, which is implemented as a semitransparent window, are not illustrated in Figure 1A

but are explained with reference to Figure 2 and 3. The semitransparent window can also be, for example, a so-called Brewster window.

A support unit 30, which is made of a solid, heat-conducting material, for example brass or platinum, and can be regarded as a housing part, encloses a core proper of laser unit 2, specifically a laser diode unit 34, in which laser beams are generated in the junction region between rhw p-layer and n-layer in a fashion known in the case of semiconductor lasers. The layer designated as laser diode unit 34 is, according to Figure 1, located directly on support unit 30. There follow, starting from laser diode unit 34, a first insulation layer 33, a piezoelement 32 as a pressure-generating element, and a second insulation layer 31, which is in contact on its other side with enclosing support unit 30. In this way, piezoelement 32 is electrically insulated.

With the previously described structure of laser unit 2, it is now possible, through a force generated in piezoelement 32, to act on laser diode unit 34 in order in this way to alter the wavelength, since the spacing between the valence band and the conduction band—and thus the wavelength—is dependent on the force acting on laser diode unit 34.

Piezoelement 32 is preferably fabricated from a tourmaline crystal provided with a silver film on its surface, which film was generated by evaporation and is employed for contacting and thus controlling the entire piezoelement 32. In place of a silver film, aluminum or another metal film can also be applied by evaporation.

As has already been explained, generating a laser beam with laser unit 2 requires both a mirror unit and also an exit window, which are arranged substantially transversely to longitudinal axis 40 of laser unit 2 (Figure 1A or 1B). While the rear mirror reflects the light beams generated by laser diode unit 34 as totally as possible, the exit window has the task of allowing light beams that satisfy predetermined conditions to escape from laser unit 2—right through the semitransparent window. Further information can be found in the publication "Understanding Lasers" by Jeff Hecht (pages 110 and 111, Second Edition, IEEE Press, New York, 1992).

A further embodiment of a part of laser unit 2 is illustrated in Figure 1B with reference to a section parallel to a longitudinal axis 40, analogously to Figure 1A. As already in the embodiment according to Figure 1A, support unit 30 of the embodiment according to Figure 1B also forms a cavity in which there are contained two insulation layers 31 and 33, a

piezoelement 32 and a laser diode unit 34. In contrast to the variant embodiment according to Figure 1A, laser diode unit 34 is initially enclosed by first insulation layer 33, next by piezoelement 32 as a pressure-generating element, then by second insulation layer 31, and finally by support unit 30. In this way it is possible to generate with pressure-generating element 32 a force that acts on laser diode unit 34 from all radial directions, that is, substantially perpendicularly to longitudinal axis 40.

Illustrated in Figure 2 is an exit window 50 as it is arranged axially on support element 30 illustrated in Figure 1. Exit window 50 essentially comprises a frame element 70 and a laterally arranged insulation layer 61, an opening 60 being provided both through frame element 70 and through insulation layer 61. Also drawn in Figure 2 is a cutting plane A-A, which forms the basis for the section through the exit window 50 illustrated in Figure 3.

Figure 3 depicts exit window 50, illustrated in Figure 2, in section along cutting plane A-A (Figure 2). Through the section parallel to longitudinal axis 40, frame element 70 becomes a U-shaped part into which there is inserted a semitransparent window 51, which stands substantially perpendicular to the propagation direction, that is, to longitudinal axis 40. A displacement of semitransparent window 51, both

translationally in the axial direction and also as a tilting movement about longitudinal axis 40, is achieved with the aid of positioning elements 52 to 56 (also referred to more generally as displacement elements in what follows), which in turn are fashioned as piezoelements. So that there will be three degrees of freedom for the movements of semitransparent window 51, positioning elements 52 to 56 in the embodiment illustrated in Figure 3 are arranged at the corners of four-cornered semitransparent window 51. Further, positioning elements 52 to 56 are individually contacted via an electrical connection so that positioning elements 52 to 56 can be driven independently of one another. Control takes place for example via a central control unit, which is not further illustrated.

The mirror unit, which is to reflect the light beams generated in laser diode unit 34 (Figure 1) in as total and loss-free a manner as possible, can be implemented as a fixed mirror surface in accordance with the known art.

In a further embodiment of the invention it is proposed to implement the mirror unit not as fixed, but analogously to semitransparent window 51, explained with reference to Figures 2 and 3. In this variant embodiment, to be sure, no semitransparent window is necessary. For this reason, in place of semitransparent window 51 illustrated in Figure 3, what is needed is a reflective surface that is obtained for example by evaporating

a metal film onto a support. The remaining elements, that is, the positioning or displacement elements, are employed for controlling the reflective surface. In this way there is created a laser unit 2 that exhibits an application range expanded relative to the embodiment having a fixed mirror surface (mirror element), as will become particularly clear in light of the discussion that follows.

In order to obtain a resonance in a laser unit, it is known to be of decisive importance that the spacing between the mirror surface (mirror element) and the semitransparent window be a multiple of, or exactly equal to, half the wavelength of interest ($\lambda/2$). If now, according to the present invention, the wavelength is altered by alteration using piezoelement 32 (Figure 1), then an efficient laser unit (i.e., maximally coherent light) can be obtained above all when the spacing between the mirror surface and semitransparent window 51 is set as a multiple of, or equal to, half the wavelength of interest.

It has been found that, through the combination of force exertion on laser diode unit 34 from all sides (Figure 1B) and the simultaneously performed correct setting of the spacing between the mirror surface and semitransparent window 51, there is made available a laser unit 2 (Figure 1) having extreme versatility of setting,

which is distinguished in particular in that the wavelength can be set electrically between, for example, 400 nm and 700 nm without the need for prisms or chromatic filters or, without the need to perform frequency doubling.

Figure 4 depicts laser unit 2 comprising the individual parts explained with reference to Figures 1A, 1B, 2, and 3. Thus support element 30 according to Figure 1 is arranged between frame element 50 having the semitransparent window and a mirror unit 80, an insulation layer 61 being present for electrical and thermal insulation between individual parts 80, 30, and 56.

Figures 5A and 5B depict laser diode units fabricated by epitaxy or also by other methods, which laser units exhibit pressure-generating elements 73, 74 on all four sides of the square cross section, the four parts of pressure-generating elements 73, 74 being spaced apart at each of the corners. In order to actuate all four parts of pressure-generating elements 73, 74 simultaneously, these are electrically connected to one another with the aid of bond wires (as illustrated in Figures 5A and 5B) or directly coupled to a voltage source or, respectively, control unit 77 provided for this purpose.

For further clarification, a p-n junction is illustrated in Figure 5A and an n-p junction in Figure 5B for the laser diode unit.

From Figures 5A and 5B it is apparent that the pressure-generating elements 73, 74 exhibit opposite poles relative to the laser diode unit, so that a mutually unfavorable influence between pressure-generating element and laser diode unit can be prevented.

The reference characters employed in Figures 5A and 5B can be identified as follows:

71 n (cathode) of laser diode unit;

72 p (anode) of laser diode unit;

73 n terminal of pressure-generating element;

74 p terminal of pressure-generating element;

75 support element;

76 source for the laser diode unit;

77 control circuit for setting the force acting on the laser diode unit;

78 air gap between the individual parts of the pressure-generating unit;

79 pressure-generating element.

In schematic representation, Figure 6 depicts a device according to the invention, having laser unit 2 arranged centrally between mirror unit 80 and exit window 50, which laser unit is implemented, for example,

in the fashion described in connection with Figures 5A and 5B. This embodiment is distinguished in that both the mirror unit 80 and the exit window 50 are displaced in dependence on the force generated by the pressure-generating element (not illustrated in Figure 6) and acting on the laser diode unit, and specifically in such fashion that the laser diode unit is always located centrally between mirror unit 80 and exit window 50 or, respectively, the diode laser facet is half the wavelength or a multiple of half the wavelength away from the mirror unit, this being dependent on whether the diode laser facet is antireflection-coated or not. Specifically, if the diode laser facet is antireflection-coated, no additional resonance builds up between the diode laser facet and the mirror unit. If, on the other hand, the diode laser facet is not antireflection-coated, then an additional resonance builds up between the diode laser facet and the mirror unit, leading to additional waves and thus to a loss if the distance is incorrect. This is with deviations depending on the distance of the mirror units relative to the diode laser facet and applies to both exit ends of the laser diode unit. This is achieved, for example, with the aid of the synchronous rotation device 100 illustrated in Figure 6, which is rotatably mounted at point D. If now mirror unit 80 is displaced with displacement element 52 in a direction W1, a 1:1 transmission to exit window 50 takes place via synchronous rotation device 100, so that the exit window experiences a displacement of identical magnitude in direction W2.

As an additional advantage, central alignment of the laser diode unit or respectively its facet yields optimized power utilization.

In place of synchronous rotation device 100, there can of course be two or a plurality of displacement elements 52 that are matched and arranged in such fashion that the laser diode unit is always located centrally between the mirror unit 80 and exit window 50.